The Effect of Soil Zone, Available Soil Nitrogen Level and Nitrogen Fertilization on the Yield and Quality of Stubble Seeded Cereal Grains

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INTRODUCTION

In discussing cereal grains as livestock feeds this paper will be restricted to the seed portion of the crops. Other papers will deal with cereal grains and perennial crops for fodder production. No assumptions have been made about the relative importance of cereal grains as opposed to fodder crops. It is hoped that the collection of papers in these proceedings will enable one to make comparisons of the relative efficiency of the various possible livestock feeds.

The yield of grain as affected by the selected factors will undoubtedly be the most important criteria. From the total yield it would be relatively simple to convert to energy. Energy has previously been described as the nutrient required in the greatest quantity by ruminant animals.

There are many quality factors important in utilizing cereal grains for feed. However, not all of these have been investigated fully with respect to soil and fertilizer effects. The protein content of cereal grains, particularly wheat, has been investigated thoroughly and so will be discussed in some detail.

In selecting data for this summary there appeared to be only one reasonable source to provide the coverage desired for Saskatchewan conditions. The Saskatchewan Advisory Fertilizer Council through the Soil Testing Laboratory is currently compiling data to revise the system of soil test based fertilizer recommendations. The complete computer aided analysis was not available at this time but the raw data was compiled and has been used in this paper. It should be noted that the data used includes work done by the following agencies:

(1) Canada Department of Agriculture, Experimental Farm, Indian Head.

(2) Canada Department of Agriculture, Research Station, Melfort.

(3) Canada Department of Agriculture, Experimental Farm, Scott.

(4) Canada Department of Agriculture, Research Station, Swift Current.

(5) Soil Science Department, University of Saskatchewan.

The use of the data for this summary is gratefully acknowledged.

The data was mainly from the years 1965 to 1969 with a small number of experiments from 1963 and 1964. The rates of N varied considerably but rates of 20, 30, 40, 60 and 80 lb N/acre were most often used. Rates in excess of 20 lb N/acre were, with few exceptions, applied as a broadcast application. The source of nitrogen was usually ammonium nitrate but urea and ammonium sulphate were used occasionally In this summary no attempt has been made to separate sources. Phosphorus was always applied seed placed at rates ranging from 20 to 40 lb P_2O_5/acre. The phosphate treatment was used as the "check" treatment in determining the nitrogen response.

To provide data in summary form for the entire province it was necessary to make several groupings of soils and soil nitrogen levels. To separate all six recognized soil zones and the six current soil nitrogen benchmarks would result in a great deal of fragmentation of the basic data. For this reason the Black and Thick Black soils were dealt with as a group as were the Grey Black and Grey soils. The placing of specific soils in to the combined soil zones was not always arbitrary. For example Tisdale soils were placed in the Black and Thick Black group whereas Whitewood soils were placed in the Grey-Black and Grey group.

Similarily the soil test values were grouped in to three categories, i.e. 0-30 lb N/acre to 2 feet, 31-60 lb N/acre and 61+ lb N/acre. It is recognized that these levels do not correspond directly to current soil test benchmarks but it was felt that these separations would serve the purpose of this paper.

The data included a wide range of soil conditions and soil test levels. The distribution of soil test N levels (Table 1) indicate that a representative range of soils were included. The distribution corresponds quite well to that obtained from soil test summaries. For example, the Grey and Grey Black soils had 64% of trials with soil tests of less than 31 lb N/acre with only 13% of trials where soil tests were greater than 60 lb N/acre. In contrast the Black and Thick Black soils had only 15% of the trials with soil tests of less than 31 lb N/acre.

Also of interest is the fact that the smaller sample of fields where protein information was also available (Table 1) showed a very similar soil test distribution. This perhaps indicates that with careful selection a smaller population of plots would meet the objectives of many projects. However, this approach would require more co-ordination between research agencies than has been the case in the past.

Table 1. Number of experiments and soil test nitrogen distribution.

Soil Zone	Number of Experiments	% of Experiments with Soil Test N 0-30	31-60 (lb/acre to 2 feet)	61+
WHEAT				
Brown	62(44)*	40(41)	52(48)	8(11)
Dark Brown	87(68)	31(35)	44(38)	25(27)
Black and Thick Black	98(43)	15(16)	42(40)	43(44)
Grey and Grey Black	55(31)	64(74)	23(16)	13(10)
TOTAL	302(186)			
BARLEY				
Brown	10(1)	40	40	20
Dark Brown	33(13)	40(31)	45(54)	15(15)
Black and Thick Black	32(14)	9(21)	56(43)	35(36)
Grey and Grey Black	61(15)	61(60)	23(40)	16(0)
TOTAL	136(43)			

*The first number indicates the total number of experiments. The numbers in parentheses refer to those experiments where protein as well as yield information was available.

THE EFFECT OF SOIL ZONE AND AVAILABLE SOIL N LEVEL

Wheat

The yields of stubble seeded wheat increase in going from the Brown to Dark Brown soil zones and a further increase was noted in moving from the Dark Brown to Black soils (Figure 1). The weighted average yields for the Grey soils were comparable to yields in the Brown soil zone.

The available soil nitrogen level also had a marked effect on the yield of the phosphate treatment. For example, the average yield on Dark Brown soils with greater than 60 lb N/acre was approximately 5 bu/acre higher than for Black soils with less than 31 lb N/acre. The yields of stubble seeded wheat on Grey soils are highly dependent on soil nitrogen level. The lowest average yields (14.5 bu/acre) were recorded for Grey soils with less than 31 lb N/acre. This further emphasizes that low available soil nitrogen is one of the main factors contributing to low yields for stubble seeded crops on Grey soils.

The protein content* of stubble seeded wheat (Figure 2) decreases in going from the Brown to the Grey soil zones. In general, higher protein values were associated with high soil nitrogen values. However, in three of the four zones there was little difference between the protein contents of trials in the 0-30 lb N/acre and the 31-60 lb N/acre range. Thus, it may be concluded that there is no direct linear relationship between available soil nitrogen and protein content of wheat. This is to be expected as other factors such as moisture stress also have a significant effect on protein content. Nevertheless, a plot of all available soil test and protein data (not shown here) has indicated that available soil nitrogen values of greater than 60 lb/acre almost always give rise to wheat protein of

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*In Figure 2 and throughout this paper protein is expressed as %N x 5.7 on a 13.5% moisture basis.

greater than 13%.

The total protein yields (Figure 3) show maximum protein production in the Black soil zones with minimum values in the Brown and Grey zones. Protein yields for Dark Brown soils were intermediate to the above mentioned extremes. The low values for the Brown soils are a result of the low yields for those soils. It should be noted that the protein yields shown in Figure 3 arise from computation of protein data from Figure 2 and yields for the same experiments. Thus Figure 3 does not arise directly from Figures 1 and 2.

Barley

The data for barley (Figues 4, 5 and 6) show similar trends as shown previously for wheat. The relative yields of barley (Figure 4) are much higher in the Brown soil zone than were wheat yields but the barley data is supported by relatively few observations. The protein contents (Figure 5) decrease in going from the Dark Brown to the Grey soil zone. Total protein values were maximum in the Black zone.

Direct comparisons of grain yields and protein yields of wheat and barley are given in Figures 7 and 8. Barley gave higher grain yields in all cases. The large difference between the two grains for Brown soils may not be truly representative as the barley values are from very few observations. Total protein yields were higher for barley on Grey soils whereas wheat gave higher protein yields on Dark Brown soils. Barley appeared to give higher protein yields on Black soils with the exception of the 0-30 lb N/acre category.

THE EFFECT OF NITROGEN FERTILIZATION

The data on the effect of applied N included a number of different types of experiments on widely different soil and climatic regions. Not all experiments had the same rates of application. In summarizing the data the response to each individual rate was averaged for all experiments with that rate. Consequently, the data for different rates is supported by varying numbers of observations. No statistical curve fitting was conducted. For this reason the individual points, and the number of observations supporting the points are shown.

Nitrogen applied to stubble seeded wheat (Figure 9) had different effects depending on the soil zone. The data in Figure 9 includes all levels of available soil nitrogen. Therefore, the response curves could be considered as the average response for the soil zones. As might be expected, the slope of the response curve is greater for Grey soils. This is undoubtedly related to the lower average soil N levels of Grey soils and the generally favourable moisture regimes of that area. When one considers the rather wide range of experimental techniques and soil conditions included, the average response curves are quite consistent.

The average response curves for a given soil zone do not take in to account the specific level of available soil nitrogen. The available nitrogen level of Dark Brown soils has a marked effect on the nitrogen response pattern as is illustrated in Figure 10. Data for the other zones showed similar types of separations with the exception of the Black and Thick Black soils. For this zone the response pattern was somewhat inconsistent. The data included very few observations of Black soils with less than 31 lb N/acre. Further investigation will be required to determine the reason for the apparent discrepancy.

The corresponding data for barley showed similar trends to wheat. The smaller volume of data for barley gave rise to more inconsistencies in the response curves (Tables 2 and 3).

Table 2. Average stubble barley yields (bu/acre) as affected by nitrogen additions.

	N Applied (lb/acre)					
Soil Zone	0*	20	30	40	60	80
Dark Brown	34.7(33)**	36.9(33)	37.7(14)	39.1(33)	39.9(8)	46.6(6)
Black and Thick Black	41.2(32)	47.0(30)	42.1(3)	51.2(31)	47.5(11)	72.5(9)
Grey and Grey Black	31.6(61)	36.8(51)	34.5(6)	40.7(58)	46.9(21)	35.5(6)

* This treatment would include small amounts of N applied with the P source.

** Values in parentheses indicate the number of observations.

Table 3. Average stubble barley yields (bu/acre) for all soil zones, except Brown, as affected by nitrogen additions.

Soil Test	N Applied (lb/acre)					
N (lb/acre)	0*	20	30	40	60	80
0-30	29.5(53)**	35.4(44)	34.5(11)	39.2(53)	46.0(15)	39.2(7)
31-60	37.0(47)	40.9(43)	37.6(8)	44.8(43)	44.9(18)	58.4(11)
61+	41.9(26)	45.3(24)	42.3(4)	47.1(26)	47.9(7)	52.7(2)

* This treatment would include small amounts of N applied with the P source.

** Values in parentheses indicate the number of observations.

The effect of nitrogen fertilizers on the protein content of cereal grains is not simple. Thorough searches* of the literature reveal a strong interaction between moisture and nitrogen in determining the protein level of cereal grains. Under conditions of adequate moisture the effect of added nitrogen is mainly to increase yield, with little effect on the protein content. With very severe moisture stress yield is usually low and protein high irrespective of nitrogen additions. Under conditions of moderate moisture stress both yield and protein can increase with nitrogen additions.

The effect of N additions on the protein content of wheat (Figure 11) indicate some increases. However, with 40 lb N/acre or less these increases are small and not likely significant. At higher rates of N additions meaningful increases were obtained. These increases are normally obtained at the point where no further yield increase is observed. Therefore, it will not likely be economical for farm operators to use nitrogen fertilizer as a means of increasing protein content.

The effect of N addition on the protein content of barley (Figure 12) indicates somewhat greater increases than for wheat. This is particularly true in the Dark Brown zone where moisture stress would likely be more severe. An almost linear relationship was obtained in other zones with some exceptions. As with wheat, the feasibility of N additions to increase protein content would depend on the value of the additional protein.

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* Henry, J.L., 1971. Crop Protein as Related to Soils and Climate. Sask Farm Science: 18, No. 1, February.

Sloman, D.G., 1971. Some Factors Affecting the Protein Content of Cereal Grains. B.S.A. Thesis, Department of Soil Science, University of Saskatchewan.

CONCLUSIONS

1. The yield and protein content of wheat and barley are strongly influenced by the soil climatic zone and the available nitrogen status of the soil. The highest yields are obtained on Black soils with high available nitrogen status. The highest protein levels are obtained in the Brown soil zone and the lowest in the Grey soil zone. Maximum total protein yields are usually obtained on Black soils with high available nitrogen status.

2. The effect of nitrogen fertilizers on the yield of wheat and barley is strongly influenced by the available nitrogen level of the soil.

3. Nitrogen fertilization may increase the protein content of wheat and barley but the effects are confounded by moisture conditions. The protein content of barley appears to be increased by N fertilization to a greater degree than wheat. It is doubtful if nitrogen fertilizers will be used for the purpose of increasing protein contents.

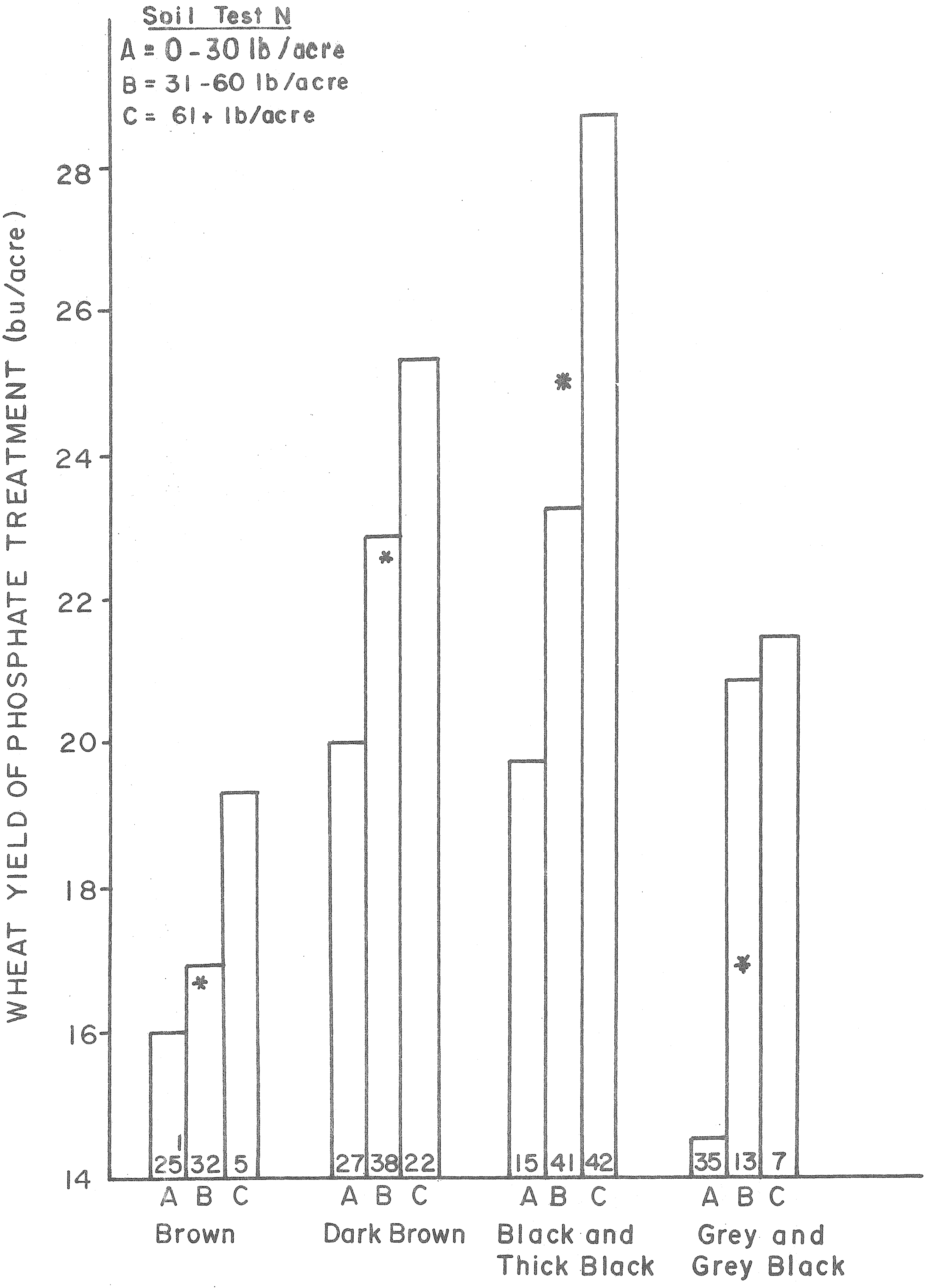

Figure 1. The effect of soil zone and available soil nitrogen on the yield of stubble seeded wheat.

[1] number of observations
* weighted average for zone

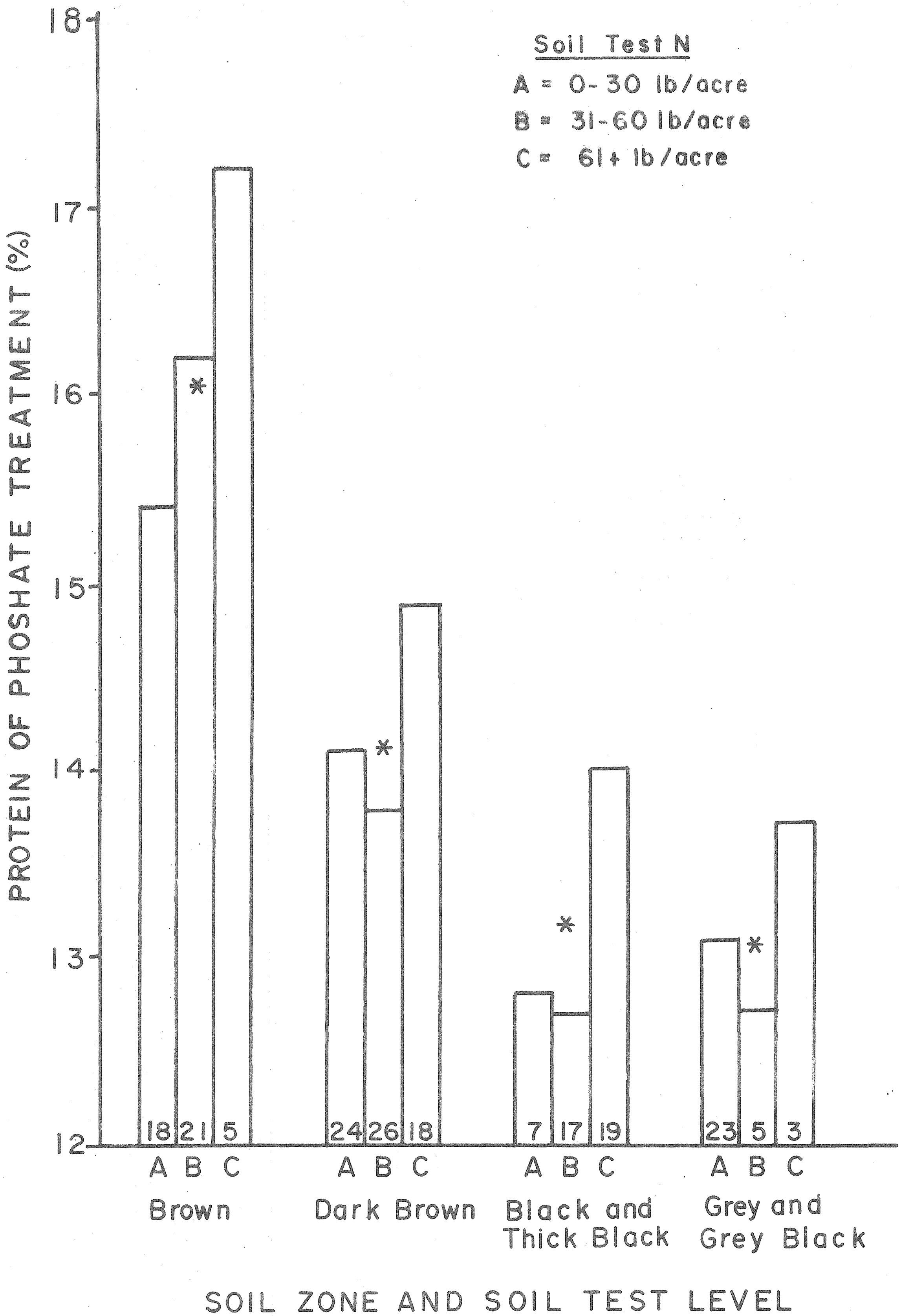

Figure 2. The effect of soil zone and available soil nitrogen on the protein content of stubble seeded wheat.

* indicates no. of observations

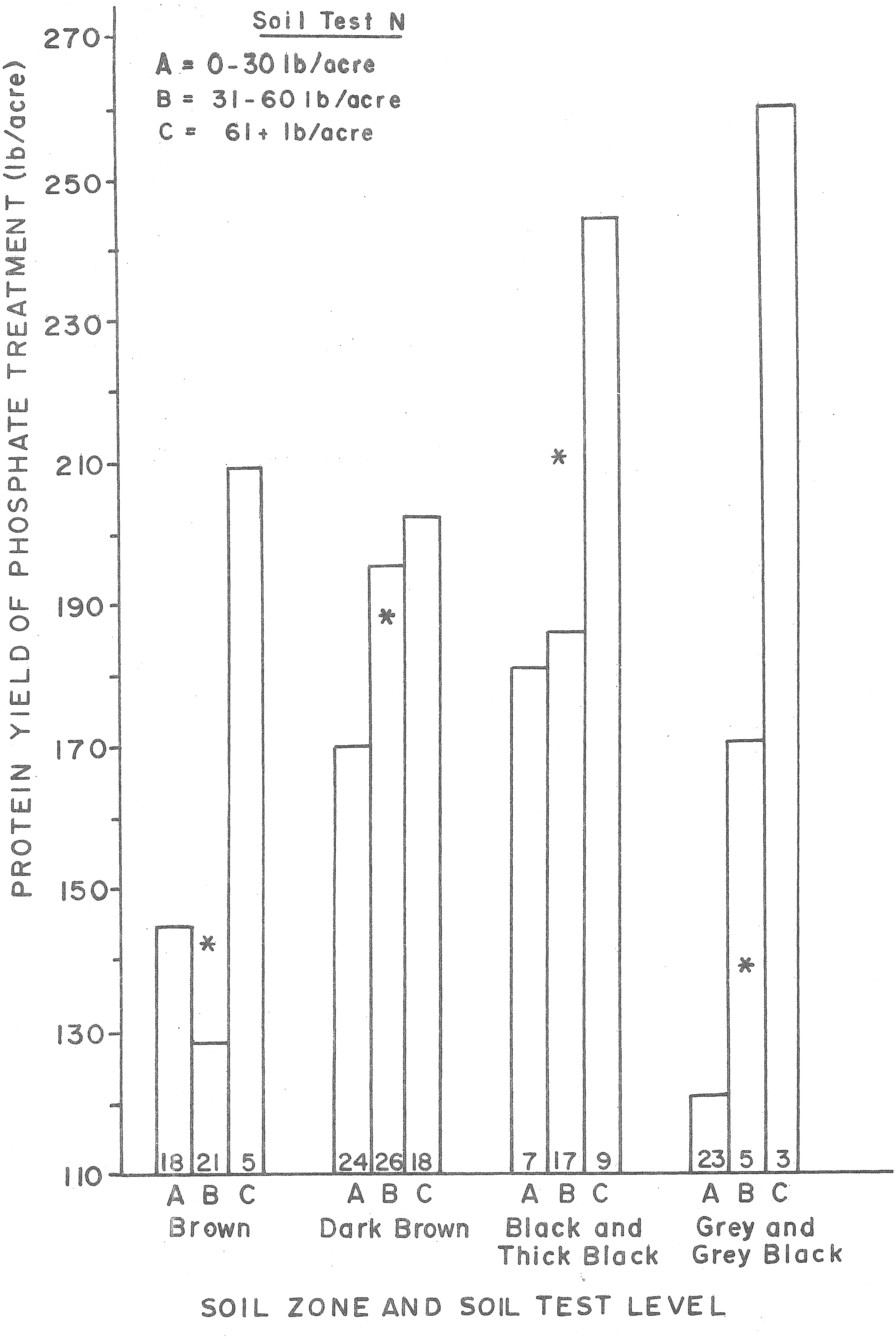

Figure 3. Total protein yields of stubble seeded wheat

* no. of observations

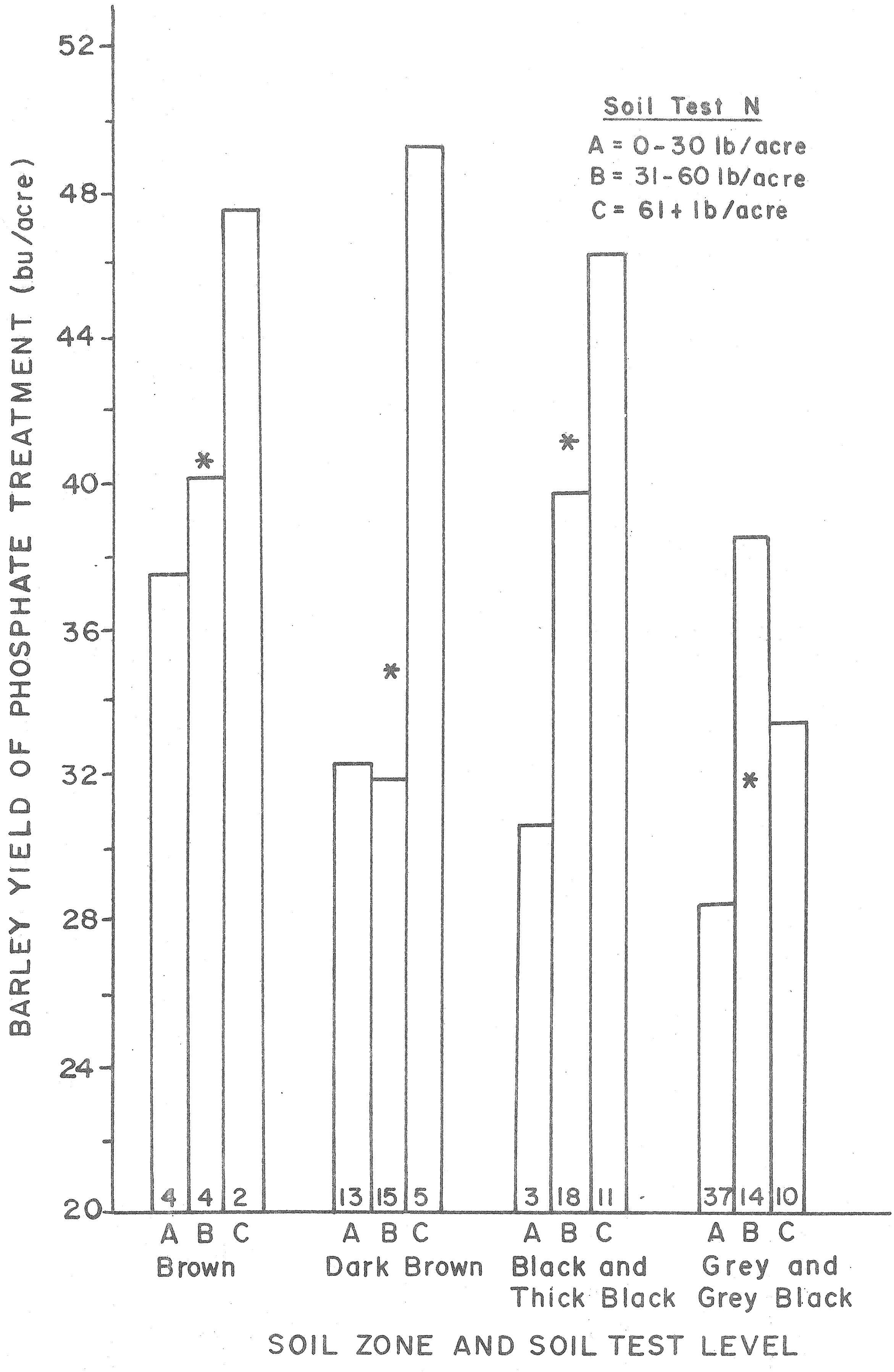

Figure 4. The effect of soil zone and available soil N level on the yield of stubble seeded barley.

* indicates no. of observations

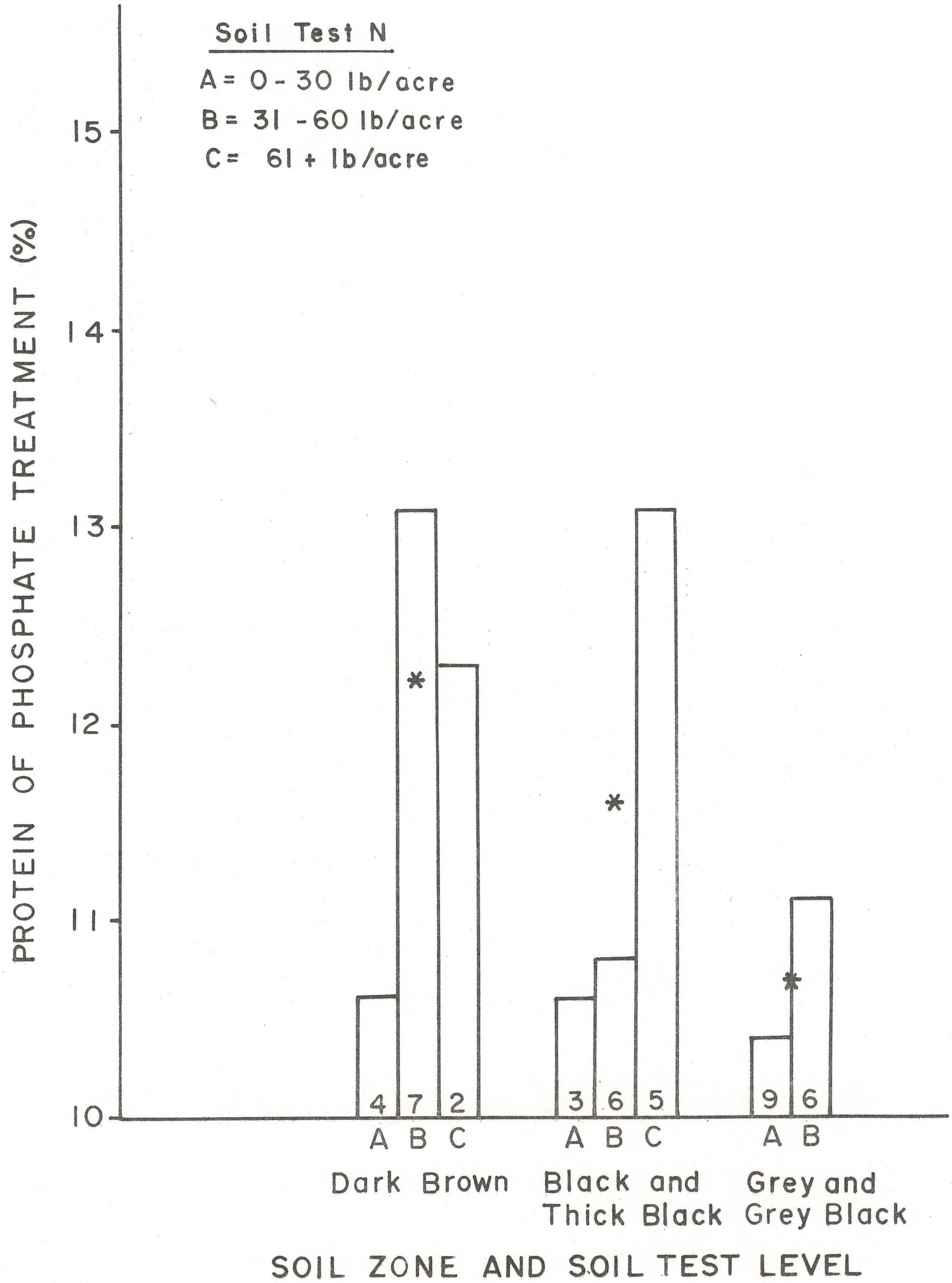

Figure 5. The effect of soil zone and available soil N level on the protein content of stubble seeded barley.

* indicates no. of observations

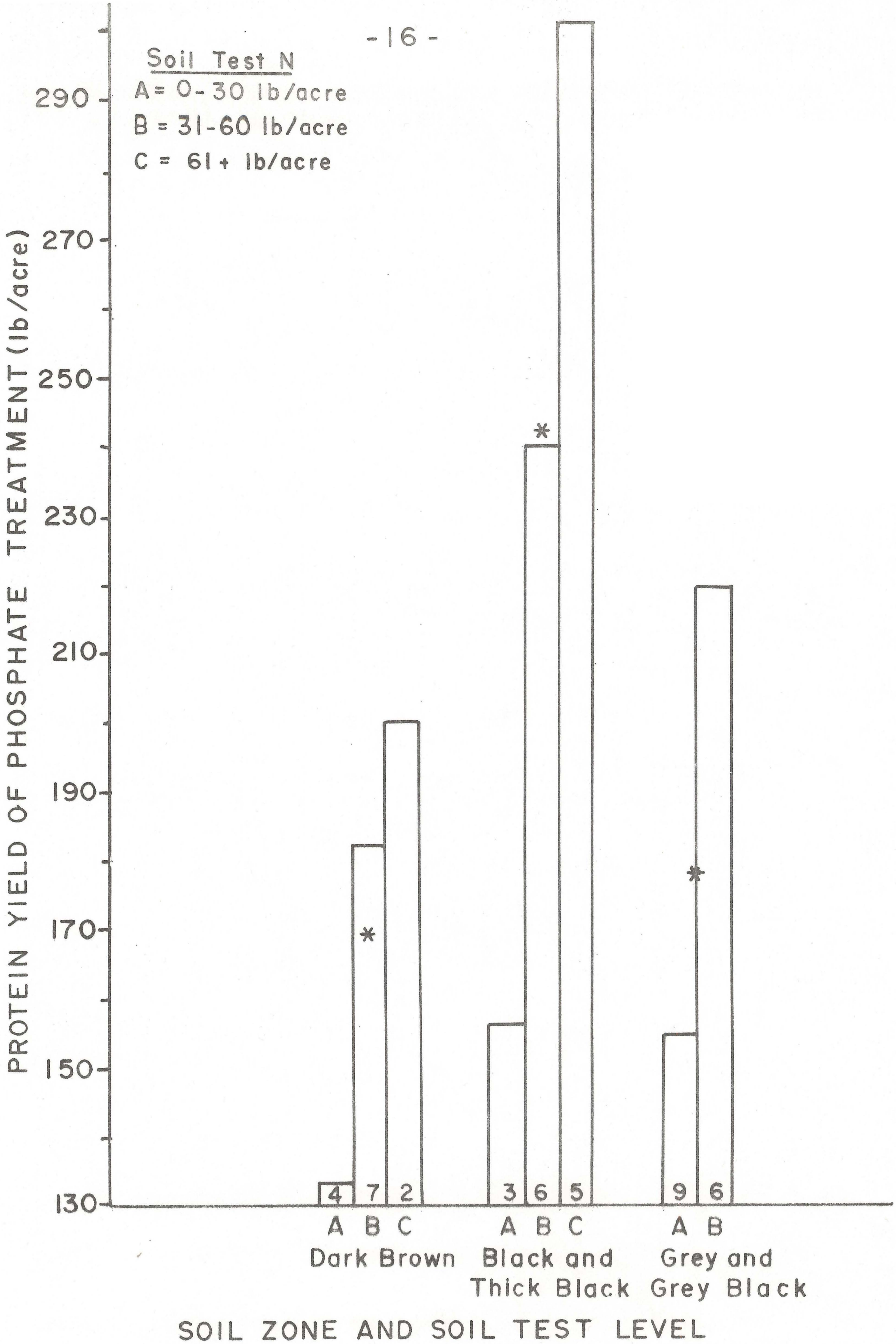

Figure 6. Total protein yields of stubble seeded barley.

* indicates no. of observations

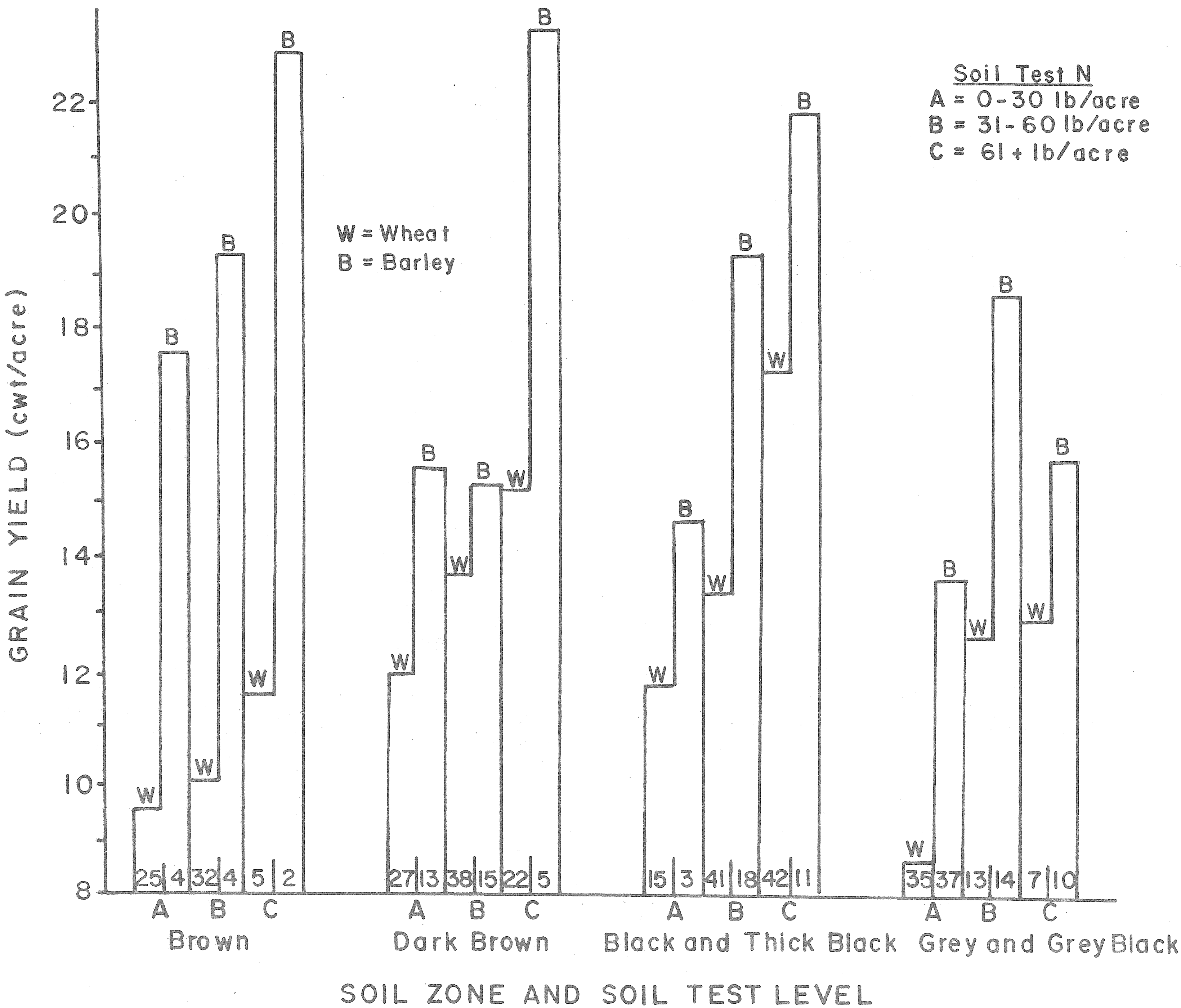

Figure 7. Grain yields of stubble seeded wheat and barley.

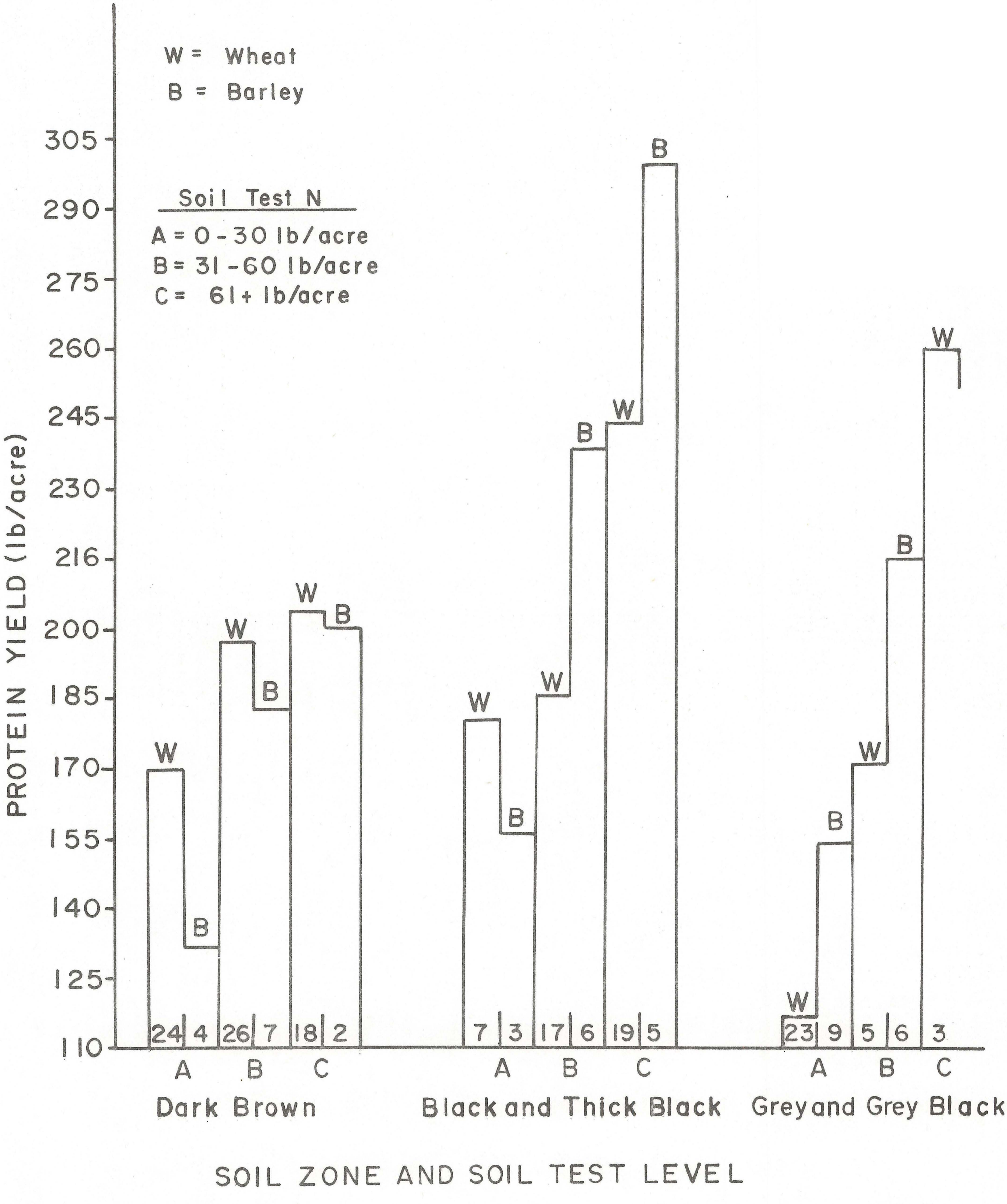

Figure 8. Protein yields of stubble seeded wheat and barley.

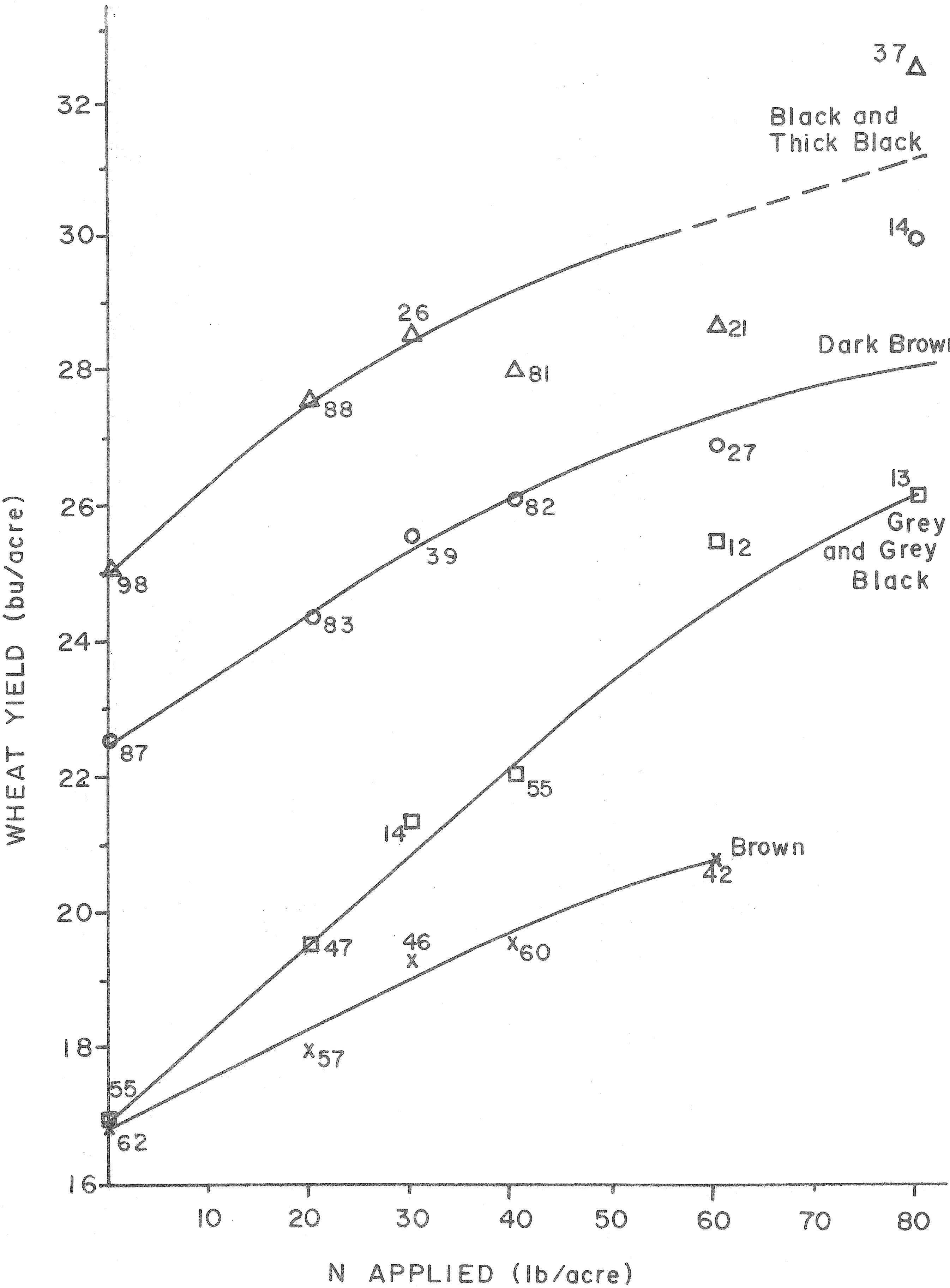

Figure 9. The response of stubble seeded wheat to applied nitrogen.

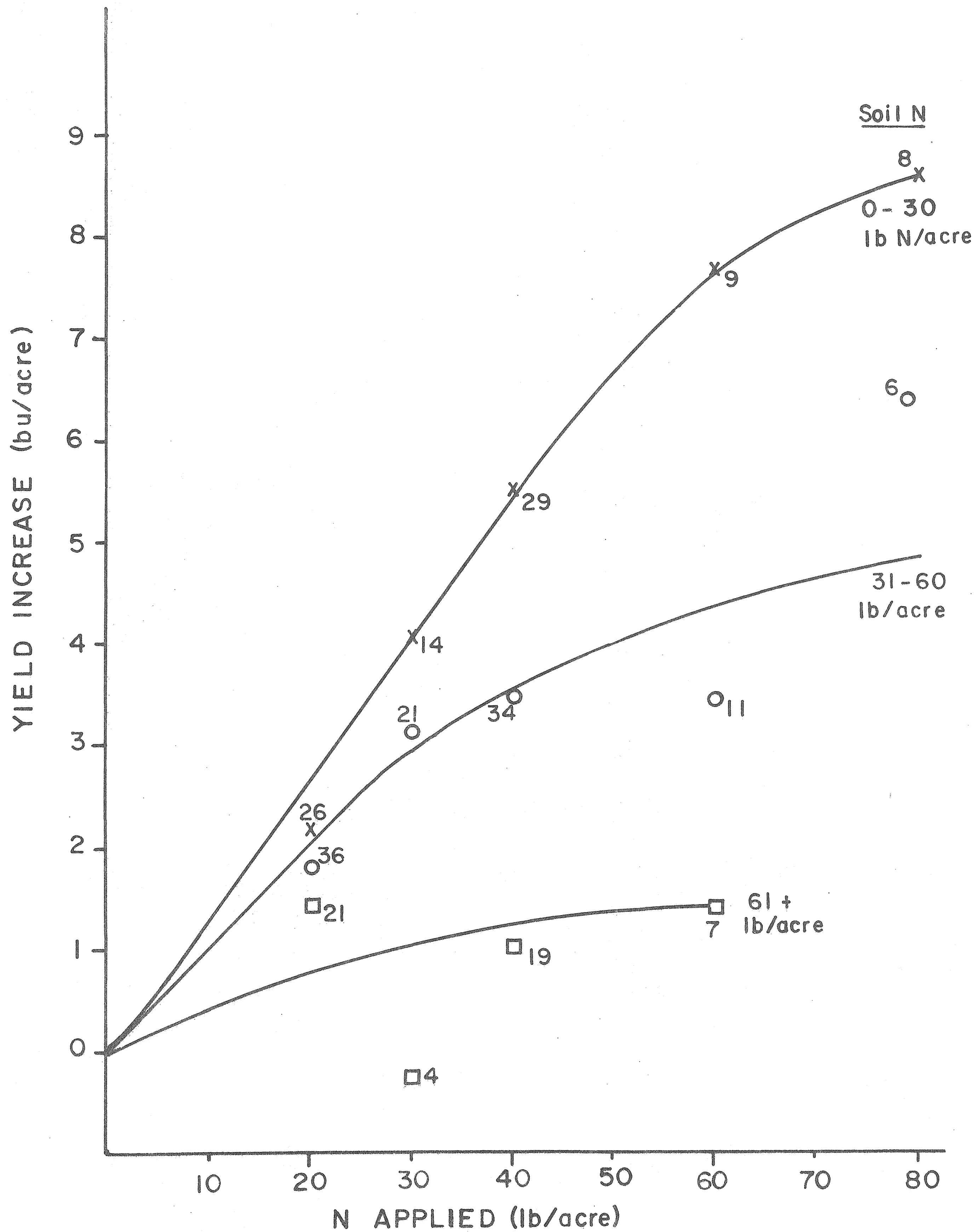

Figure 10. Nitrogen response of wheat for stubble seeded Dark Brown soils as affected by available soil nitrogen.

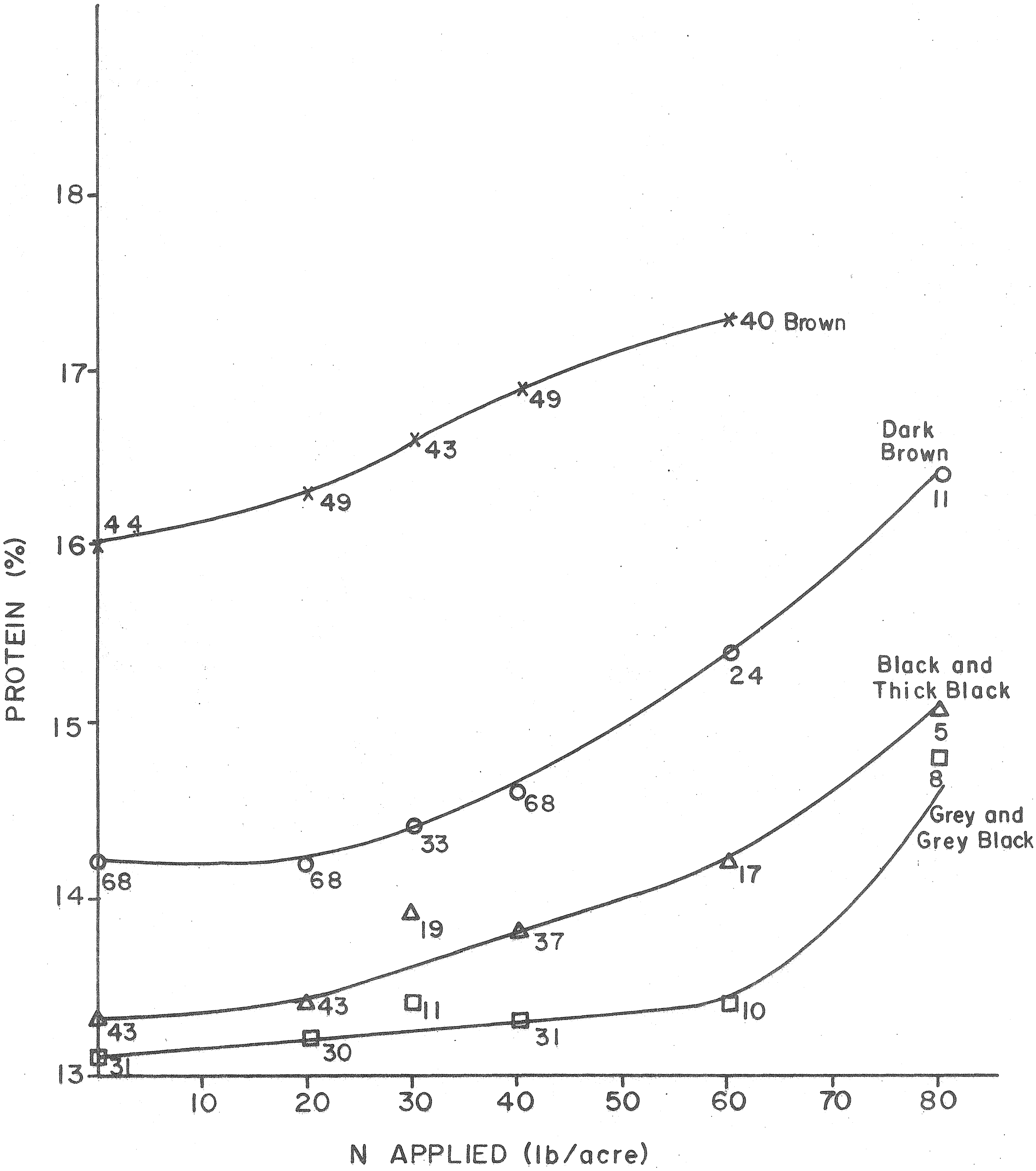

Figure 11. The effect of nitrogen fertilizer on the protein content of stubble seeded wheat.

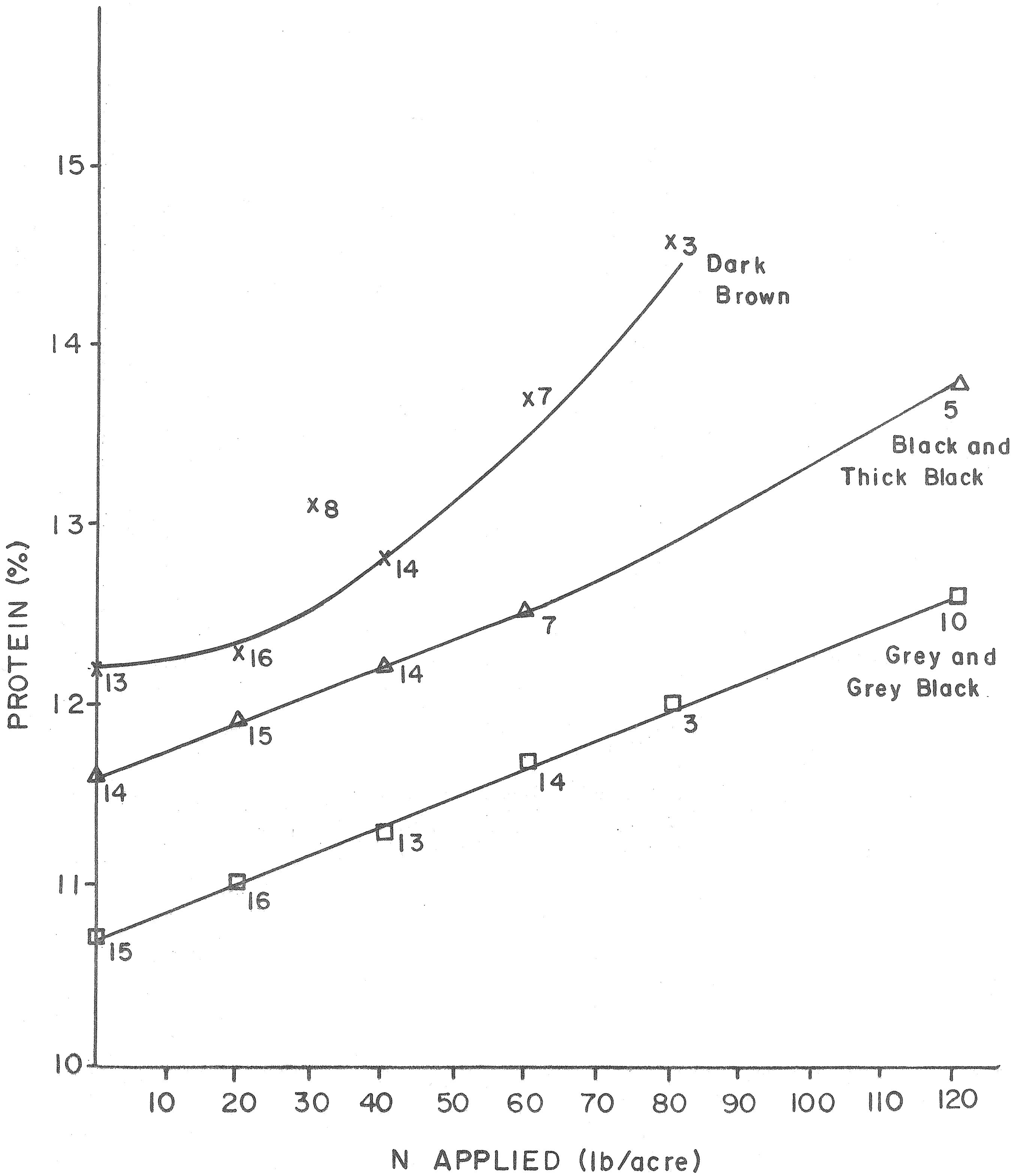

Figure 12. The effect of nitrogen fertilizer on the protein content of stubble seeded barley.